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Human Reaction to Vibration

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1. Introduction

As must be obvious from the content and tone of some of the other papers being presented at this gathering, very little reliable and consistent information is currently available about the ways in which people react to motion stimuli,particularly to vibratory or oscillatory motions. Most of the available information relates to vertical, sinusoidal motions. Some data, unfortunately inconsistent, exists on reaction to horizontal motions, and there is a little evidence that random excitation is less disturbing than sinusoidal.

Some indication of the extent of the confusion is given by Fig. 1. This figureis a composite of three figures in Hanes (Ref.1). Three bands are shown, which are envelopes of the detailed plots done by Hanes. It can be seen that the band labelled 'intolerability' largely overlaps that labelled 'discomfort', whilst there is a much smaller overlap by the 'discomfort' band of the 'perception' band. Even more significant than the overlaps is the width of each of the bands concerned. Different authors reports on the level of 'just perceptible' vibration quote levels differing by factors of forty to one. Levels of 'discomfort', admittedly a difficult concept, vary by one hundred to one.

These variations are based on quoted 'mean' values, and take no account of the known high variability to be expected in experiments involving subjective reactions. Hence, the opening statement concerning lack of consistent or reliable data.

It is felt that this lack stems from three main causes. The first is that most of the published work was carried out by engineers to rigid engineering requirements which ignored the essential difficulties involved in carrying out human subjective experiments, and the wide range of techniques available for dealing with these difficulties. The second stems from careless or incomplete reporting of the engineering side of the experiments. The third is linked with the second and arises from the fact that the waveforms used in the excitation, although nominally sinusoidal, were probably nothing of the sort when measured as acceleration time curves.

2. Aims of work at University College, Swansea

The work currently being done at Swansea is aimed at establishing the shape of mean curves which represent the way in which subjective reaction varies with a measure of the physical motion, and discovering the way in which the shape changes with 'level' of the subjective reaction.

To achieve this aim it must first be possible to evaluate subjective reaction to vibration, and secondly to establish some parameter which represents the physical motion. Some progress has been made on both these counts, and will be described in the following sections.

Limitations of available equipment have decreed that the work carried out so far has been done using excitation to the subjects' hands or feet by means of relatively small electromagnetic vibrators. The frequency range used has been from 5 Hz to 100 Hz., although excessive distortion at the lower frequencies has meant an effective lower frequency of 25 Hz. The amplitude of the excitation has been limited to ± 0.25 in.

3. Subjective testing

A preliminary study was carried out in which a variety of standard psychophysical techniques were evaluated as methods of establishing levels of subjective response to vibration. As a result two techniques were selected as being the most promising on the available evidence, although this choice still needs to be confirmed for whole body vibration experiments.

The first technique is a straightforward magnitude estimation technique. The subject is presented with a line with two points marked on it about 10 cm apart. Two standard vibrations, one evoking low subjective response, and one evoking a high one, are presented and the subject is told to regard the positions of the points on the line as corresponding to the two excitations. He, or she, is asked then to rate a series of test excitations, usually ten or so in number, by putting points at appropriate points on the line.

The second involves a cross-modality matching. So far noise has been used as the matching stimulus, but there are difficulties because of the effect of background noises. Other matching stimuli are being tried at the moment to select an appropriate one. It is hoped that this technique will prove to be usable in field trials as well as in laboratory experiments.

Some attempts have also been made to determine a threshold of perception to use as a 'subjective zero', but the equipment appears to have a controllable threshold above that of the threshold of subjective response.

4. Measurement of the physical parameters.

Attempts have also been made to determine which of the possible vibrational measures provides the best results. Sinusoidal excitation is used, despite the problems still to be overcome in connection with distortion of the waveform by the equipment.

Both rank order and product moment correlations have been carried out between the measure of subjective reaction, as distance along the line or as noise level, and various possible measures of the vibration. Vibration measures used were vibration amplitude a, peak velocity (obtained as af where f is the frequency), peak acceleration, peak jerk (af^3) and 'absorbed power' (a^2f^3). On both correlation patterns vibrational velocity gave very high correlation, whereas the other parameters did not do so well. This ties in to some extent with what has been thought in the past about response in the frequency range 25 Hz to 100 Hz.

Sinusoidal excitation has been chosen because it is one of the simplest waveforms which can be defined unequivocally. There are many advocates of the use of random excitation for this sort of work, on the grounds that it is more 'realistic', but the authors do not accept this. There are too many unknown factors present when one tries to use random vibration at such an early stage in this sort of investigation.

Ref. 1. HANES, R.M. Human Sensitivity to whole body vibration. Applied Physics Lab. Johns Hopkins University APL/JHU- TPR 004 (May 1970).

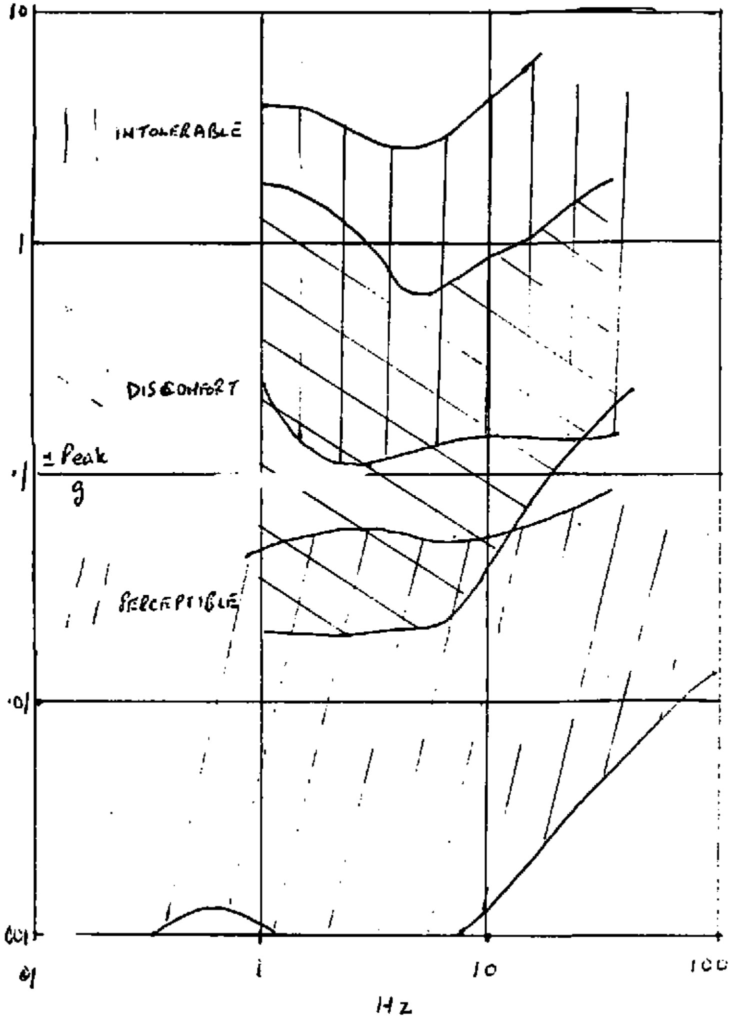

Fig 1. (After Hawes, by G.R. Allen)